Student performance in a newly developed MSc programme

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ABSTRACT
The Technical University of Denmark (DTU) offers, as a consequence of the Bologna Declaration, international Master of Science in Engineering (MSc) programmes. Thereby, one of the challenges for DTU is to evaluate international applicants with an educational engineering background and traditions other than DTUs and allow qualified students to enter the MSc programmes. The focus of the present work is a comparison of how international and Danish students perform within specific modules of the MSc curriculum in Engineering Design and Applied Mechanics at Technical University of Denmark. The admission requirements are described and the comparison is based on weighted grade averages.

Keywords
International mobility, student performance, MSc curriculum.

1. INTRODUCTION
Engineering education experiences a growing international mobility among students due to the increased internationalisation in general but also as result of the Bologna Declaration improving the European students' possibility for obtaining the bachelor degree at one university and the master degree at another. Until 2006 all Master of Science in Engineering (MSc) programmes at Technical University of Denmark (DTU) were given in Danish as part of a five years engineering education programme. However as a consequence of the Bologna Declaration, a revision of the structure of the engineering education at DTU was finished in 2007. The revision resulted in three-year Bachelor of Science in Engineering (BSc) programmes and two-year MSc programmes, corresponding to 180 ECTS and 120 ECTS programmes, respectively. DTU also offers 3.5-year, 210 ECTS, Bachelor in Engineering (BEng) programmes. However, they have not been influenced by the above mentioned revision of the engineering education. Both the BSc and BEng programmes are offered in Danish. Furthermore, as a consequence of the increased international mobility DTU changed its recruiting focus into attracting not only Danish but also international MSc students. Thus, the MSc programmes are offered in English to both Danish and international students. The educational structure at DTU is schematically shown in Figure 1.

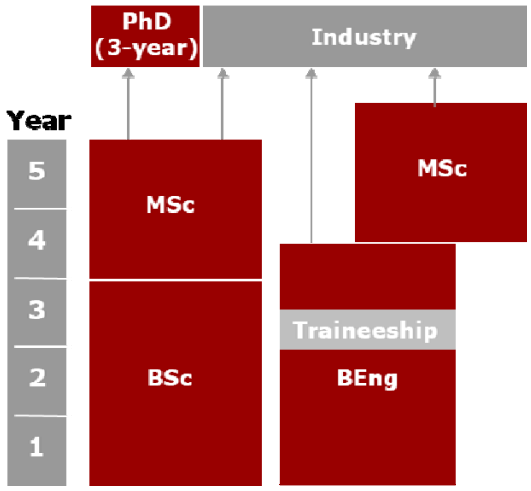

Figure 1. The engineering education structure at DTU.

In literature, the influence of the Bologna process on the engineering education curricula is discussed in e.g. [1]-[4]. Thus, [1]-[2] address the consequences and challenges of the Bologna process on the development of engineering education in Europe and describe briefly how some of the countries deal with it, while the process and design of the engineering education curricula are described in [3]-[4]. In [3] the development of mechanical engineering curricula based on a 5-year course leading to the master degree at the University of Minho, Portugal, is presented. The

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design of a new 2-year Master of civil engineering curriculum as a second-cycle course at University College Dublin, Ireland, is described in [4]. Studies on the academic performance of university students, assessment preferences, and supervision of international masters' students are reported in e.g. [5]-[9]. The study in [5] investigates the relationship between student origin and performance in accounting courses at University of Newcastle, Australia, by comparing the performance of resident and international students. A study on determining which factors significantly predict the success of students admitted to the Master of Information Science programme at the University of Ibadan, Nigeria, is presented in [6]. The effects of various academic and cultural-related factors on academic performance of the Master of Science international students in the School of Management at University of Surrey, UK, is presented in [7] having focus on the differences between Chinese and non-Chinese cultural groups. Assessment preferences are addressed in [8] as it examines student's view and experiences of assessment and performs a comparison of UK and international students, while [9] consider the nature of the supervision of international masters' students.

For the MSc programmes at DTU, the main part of the Danish students has a BSc or BEng degree from DTU and their educational background is thus well-known to the university, while the international MSc students comes from all over the world, although the tuition fee has reduced the number of students from countries outside EU/EEA. Thus, offering international MSc programmes one of the challenges for DTU is to evaluate international applicants with an educational engineering background and traditions other than DTUs and allow qualified students to enter the MSc programmes. Since DTU wishes to give both Danish and international students the best options for success during their MSc study it is relevant to raise the question whether the evaluation criteria used for enrolling international students are too strict, too weak, or adequate. The present work addresses this question for the MSc programme in Engineering Design and Applied Mechanics. The answer to this question is of importance for the procedure used in evaluating international applicants as well as for the development of the curriculum of the programme.

2. ADMISSION REQUIREMENTS

The MSc programmes offered are at advanced academic levels, and a thorough basic knowledge of an engineering discipline related to the MSc programme is required for admission. Information for prospective MSc students, e.g. the admission requirements, is available at the DTU homepage, [10]. The university uses online application and the applicant has to include documents like certified copy of diploma/transcript, two academic letters of reference in English, the applicant's motivation for applying to DTU and to the specific MSc programme (statement of purpose), CV, and IELTS/TOEFL score in accordance to the DTU language test requirements. The university then performs an individual evaluation of each international applicant with respect to admission based on the following general criteria, [10]:

- *Degree*: Bachelor degree in Engineering obtained at an internationally recognized university.
- *Specific requirements*: The specific entry requirements for each individual MSc programme.
- *Grade point average*: At least 75% of the maximum obtainable grade. Can vary depending on the grading system of the university awarding the Bachelor degree.
- *English language proficiency*.

For each of the MSc programmes DTU has among its faculty members appointed programme coordinators who are responsible for among other things the formulation of the content of the programme, the programme's specific admission criteria (the Degree and Specific requirements), as well as the individual evaluation of the specific programmes' applicants. Prospective MSc students can at the DTU homepage find further details on Degree and Specific requirements for each MSc programme as well as the content of the programme, including descriptions of the course modules within the programme.

3. PROGRAMME STRUCTURE

The MSc programmes at DTU are based on 120 ECTS equally divided between the four groups: General Competences (GC), Technology Specialisation (TS), Electives, and Thesis project, see Figure 2.

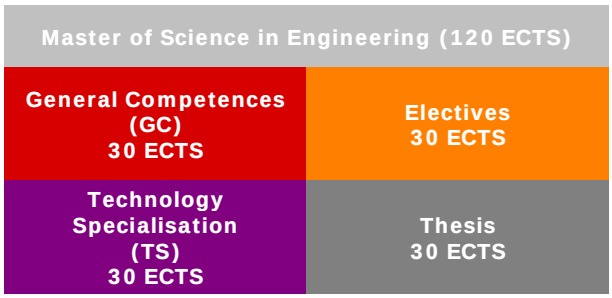

Figure 2. The structure of the MSc programmes at DTU.

Within both the GC and TS group at least 30 ECTS has to be taken among specific course modules. The General Competences group has a broader scope than the specialist competences in order to offer students the range of skills necessary to meet the complex challenges of a modern engineering job. Thus a series of competencies are to be obtained by all candidates including the generalist point of view where technology is combined with economics, management, organization and project work, the synthesis point of view in working with an open problem using teamwork and cooperation, and the normative technical skills ensuring a common academic identity for each particular MSc programme. The Technology Specialisation group and the MSc Thesis provide in-depth academic and technological training leading to state-of-the-art qualifications within the specific field of engineering. An important aspect of the MSc programmes at DTU is also the Electives group which represents a significant number of courses as it includes all advanced level courses at DTU. Since the introduction of elective course modules in the early 70'ies they have been an important and by the students highly appreciated part of the engineering education curricula at DTU. By combining GC and TS course modules with appropriate

elective courses, students can create their own individual study plans reflecting their specific field of interest.

The MSc programme in Engineering Design and Applied Mechanics and its disciplines cover both the systematic engineering design methods within engineering design and product development, and analysis, numerical simulation, and optimisation with focus on strength of structures, fluid flows, and energy conversion. A student's course of study within the programme may result in a broad-based education. However, based upon the individual student's interests he/she can make a study plan with main focus in one of the five more narrowly defined disciplines: Engineering Design and Product Development, Strength and Dynamics of Structures, Industrial Fluid Mechanics, Energy Engineering, and Maritime Engineering.

4. METHOD OF ANALYSIS

The population represents students who have started on the MSc programme in 2008 or spring 2009 and still were registered as students in June 2010. The data thus corresponds to at least 1½ year of studying with grades registered in the DTU system by June 2010. The students' entrance degree were either a BSc (21 students) or BEng (17 students) from DTU, or an international engineering bachelor degree (9 students). While all international MSc students begin their studies in the fall semester, Danish MSc students can begin their studies in the fall or spring semester.

The more specified prerequisites for the MSc in Engineering Design and Applied Mechanics with respect to the admission criteria Degree and Specific requirements were in 2008-2009: BSc degree in Mechanical Engineering, Naval Architecture, or Civil Engineering. Basic knowledge and skills in engineering design methodology, mechanics of materials and structures (statics, mechanical vibrations, strength of materials), fluid mechanics (Euler equations and Navier-Stokes equations), engineering thermodynamics and heat transfer, as well as applied mathematics, numerical methods, and elementary programming using e.g. MATLAB or Fortran.

The English language proficiency requirement was in 2008-2009: TOEFL paper-based: 573, TOEFL computer-based: 230, TOEFL internet-based: 88, IELTS: 6.5. However, in 2008-2009 the following applicants were exempted: 1) applicants who earned their degree in a country in EU or in Australia, Bahamas, Canada, Guyana, Iceland, Jamaica, Norway, New Zealand, Switzerland, Trinidad and Tobago, or USA, 2) applicants who had completed at least six months of English taught studies in a Danish university applying to a minimum of 20 ECTS, and 3) applicants who were recommended for admission by one of DTU's partner universities and who had been interviewed by DTU. These exemptions have later been changed.

Admission to the MSc programme was decided on the basis of the relevance and quality of the applicant's educational background. The applicant's grade point average or equivalent, individual grades for relevant courses, statement of purpose, academic letters of reference, and English language proficiency were taken into account. Applicants are assumed to have the necessary prerequisites for the MSc programme courses when entering the programme. At the MSc programme, students should be willing to acquire by themselves any prerequisites that they may be missing.

The focus of the present study is an evaluation of how the international students perform compared to the Danish students in one of DTU's MSc programmes, the MSc in Engineering Design and Applied Mechanics. The evaluation is based on weighted average of each student's grades obtained in course modules passed during the MSc study. At DTU either a 7-point grading scale or passed/failed is applied to assess students in course modules. The grading scale uses the grades -3, 00, 02, 4, 7, 10,

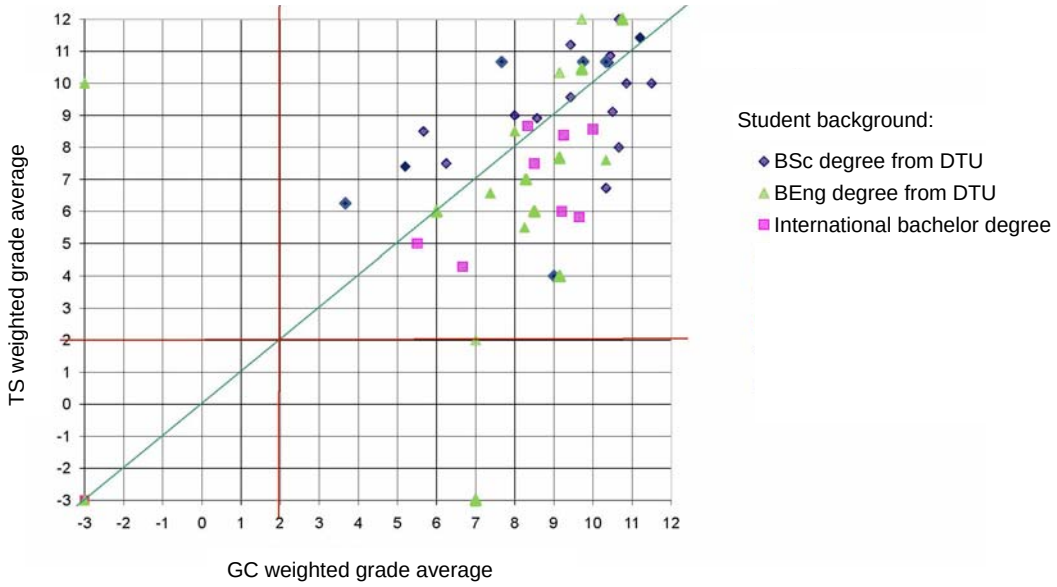

Figure 3. Weighted grade averages, Technological Specialisation courses (TS) vs. General Competence courses (GC).

12, where grade 02 is the lowest pass grade and 12 is the maximum obtainable grade.

The course modules represented in the analysis are course modules within the General Competences (GC) and Technology Specialisation (TS) groups. The GC group is for Engineering Design and Applied Mechanics, at the time of enrolment for the students analysed, divided into two groups: one group of 3 course modules corresponding to 25 ECTS of which min. 15 ECTS has to be taken, and another group of 10 course modules corresponding to 72.5 ECTS of which the student has to pass min. 15 ECTS. The TS group consists of 20 course modules corresponding to 147.5 ECTS of which the student has to pass 30 ECTS. Each course module in the two groups corresponds to either 5, 7½, or 10 ECTS. In the present analysis only course modules using the 7-point grading scale in the assessment of students are included in the analysis and each grade is weighted by the course module's corresponding number of ECTS.

5. RESULTS AND DISCUSSION

Figure 3 shows the performance of MSc students in Engineering Design and Applied Mechanics given in terms of weighted grade averages. The lowest pass grade, grade 02, is marked by the red lines in the figure. Each axis is related to the structure of the MSc programmes, and the weighted grade averages are based on each student's grades obtained for the specific course modules within the GC and TS group, respectively. The Danish students are here used as frame of reference for the performance of the international students, and the educational background is reflected in the figure by the three candidate categories: DTU BSc, DTU BEng, and international bachelor degree.

The first indication given in the figure is an acceptable performance of the international students compared to the Danish students. For the population as a whole, the figure shows a satisfactory distribution of the data around the oblique, green line, although the figure also identifies four students (3 DTU BEng and 1international candidate) who have obtained a weighted grade average below the pass grade within the TS or GC course modules (or both), and one student (DTU BEng candidate) who is at the pass grade within the TS course modules. The four students below the pass grade correspond to students who are not active within the programme. The figure also indicates an influence of the educational background in the way that the international students on average seem to obtain higher weighted grade average within the GC course modules than within the TS course modules, while the situation is the opposite for the majority of the BSc candidates from DTU. The tendency among the DTU BEng candidates is not that unambiguous. However, if the DTU BEng and BSc candidates are compared, the BSc candidates seem on average to obtain higher weighted grade average within the TS course modules than the BEng candidates. At DTU all course modules within the GC and TS groups are advanced course modules requiring prerequisites within the academic field of the specific course module, and the advanced courses are usually in their prerequisites adjusted to basic course modules offered the BSc students. The MSc course modules thus typically match BSc course modules at DTU, but do not necessarily take into account the differences when it comes to an educational background as BEng or international bachelor. This may especially be the case for the courses within the TS group as these course modules together with the MSc thesis according to the programme structure are intended to provide state-of-the-art qualifications within the specific field of engineering, while the GC group has a broader scope.

As the international students perform satisfactory compared to the Danish students a first conclusion is that the selection criteria used for enrolling international students are adequate and seem to be working satisfactory. In order to obtain further information on the international students' performance and experiences of the course modules offered within the programme it would be relevant using questionnaires and/or interviewing the MSc students of the programme and see if there is a correlation with the findings in the present study.

6. CONCLUDING REMARKS

Enrolling international students in MSc programmes can be addressed from two points of view: the universities and the student's point of view. The enrolling university wishes to have fair evaluation criteria allowing qualified students to enter the programme in order to ensure a high ratio of enrolled students to finishing candidates. The international MSc students expect, as a result of having fulfilled the evaluation criteria used by the university prior to enrolment, to have sufficient knowledge and skills to finish the programme successfully. In this paper focus is on the university perspective and the results shown in Figure 3 indicate that the international students of the MSc in Engineering Design and Applied Mechanics perform satisfactorily with respect to obtained weighted grade averages compared to the corresponding Danish students. The preliminary study presented here also indicates that adequate criteria have been used for evaluating international applicants for the MSc in Engineering Design and Applied Mechanics at DTU. The evaluation criteria encompass academic qualifications, course modules in bachelor engineering education, statement of purpose, academic letters of reference, and requirements for English language proficiency. A scope of future research will be exploring the students' perspective by using interviews and/or questionnaires focussing on both the students' motivation for submitting application to the MSc in Engineering Design and Applied Mechanics upon arrival at DTU, and their perception of DTU, Denmark, and their MSc study as DTU students after the first year of study.

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